OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE
Cosmetic

Impact of Surgical Rejuvenation on Visual Processing and Character Attribution of Faces

Thanapoom Boonipat, MD*
Nathan S. D. Hebel, BS†
Daniel Shapiro, MD*
Mitchell A. Stotland, MD‡§

Background: This study considers observers' reflexive responses to the rejuvenated face, and how instinctive responses relate to subjective judgment. We investigated observers' reflexive perception of faces both pre and post surgical intervention during the early stages of visual processing. Subjective character attribution for all test images was also assessed by the same observers.

Method: Forty frontal facial images of 20 patients portraying the pre- and post-operative high superficial musculoaponeurotic system facelift along with variable concomitant procedures were studied. Nineteen lookzone regions were mapped post hoc onto each image. Forty observers examined the images, whereas an eye-tracking camera recorded their eye movements. Visual fixation data were recorded and analyzed. Observers also rated each image on the basis of five elemental positive character attributes.

Results: A statistically coherent but nonsignificant ($P > 0.05$) trend was identified with the surgical intervention resulting in greater attention being paid to the central triangle region of the face with reduction in attention to the facial periphery. Facial rejuvenation significantly increased the subjective character ratings of all five positively valenced attributes tested. Average age estimate of the photos decreased significantly from 54 to 48.6 years (true average age of 57.4 years).

Conclusions: We provide data illustrating both reflexive and subjective responses to facial rejuvenation. Observers reported a more favorable impression of the treated faces and evaluated them as being younger than their true age. A trend was detected for increased visual fixation of the central facial region following rejuvenation. Interpretation of these findings and indication for further research is provided.
(Plast Reconstr Surg Glob Open 2023; 11:e5038; doi: 10.1097/GOX.0000000000005038; Published online 18 September 2023.)

INTRODUCTION

First impressions are largely determined by physical appearance and can contribute to a lasting positive perception in general.[1,2] Multiple studies have considered patient satisfaction following facial rejuvenation surgery and generally report favorable outcomes and an overall enhancement of youthful appearance.[3,4] However, few studies have evaluated observer impressions of patient appearance following such rejuvenative intervention. It is understood that observer impressions are formed rapidly, with initial visual processing of a face beginning within 170 milliseconds of exposure, and facial recognition estimated to occur as early as 300 milliseconds.[5–8] Tracking an observer's eye movements during facial inspection provides information about particular structural areas of reflexive interest or attraction. Accordingly, eye-tracking is a research modality that can highlight for patients and their providers areas of the face that are subconsciously considered of interest to others.[5–9] During rhytidectomy and related facial rejuvenation procedures, various areas of the face are targeted for improvement: forehead rhytids, brow position and contour, redundant eyelid skin, eyelid position and canthal angulation, glabellar lines, deepening of the nasolabial folds, jowls,

*From the *Division of Plastic Surgery, Department of Surgery, Mayo Clinic, Rochester, Minn.; †Mayo Clinic Alix School of Medicine, Rochester, Minn.; ‡Department of Surgery, Weill-Cornell Medical College- Doha, Qatar; and §Division of Plastic, Craniofacial, and Hand Surgery, Sidra Medicine, Doha, Qatar.*

Received for publication October 19, 2022; accepted February 9, 2023.

DOI: 10.1097/GOX.0000000000005038

Disclosure statements are at the end of this article, following the correspondence information.

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

cervicomental obliquity, etc. These aging cues can be perceived independently or holistically but are being processed subconsciously by an observer in the initial moments upon encountering a face. The vantage point from which a face is viewed will presumably impact which telltale aging signs are of greatest interest to the observer (eg, cervicomental angle seen best from profile view; nasolabial folds from frontal view). In the current study, we have tracked the eye movements of observers exposed to frontal images of 20 patients who underwent rhytidectomy along with a variable combination of ancillary rejuvenative interventions. This modality of evaluation serves as a proxy, representing reflexive observer detection of facial aging changes. Accompanying our measurement of instinctive responses to the aging and rejuvenated face, we have also surveyed the subjective impressions of observers to these same facial images. Possible associations between the subliminal and reported responses were studied.

Takeaways

Question: How does facial rejuvenation alter observers' reflexive and subjective assessment of the patient's face?

Findings: Analysis of 40 SMAS facelift demonstrated that facial rejuvenation increases observers' attention to the central triangle while decreasing attention to the facial periphery. Subjective ratings by observers demonstrated decreased estimate of average age and increased positive character attribution after surgery.

Meaning: Rejuvenation surgery results in a more favorable, younger, impression of the treated faces as elucidated by eye tracking and subjective reporting by observers.

METHODS

Study Participants

The participants were divided into (1) stimulus group and (2) observer-rater group.

Stimulus Group

The stimulus group included 20 consecutive patients who underwent facial rejuvenation surgery from January to December of 2017. The patients were operated on by a single aesthetic surgeon (D.S.) at one private practice center. Signed informed consent was obtained for all images, as per protocol approved by our institutional review board. Two images per patient were included in this study (ie, a total of 40 images). Photographs were obtained before and at least 3 months after surgical rejuvenation. An image pair of a representative patient is shown in Figure 1.

Observer Group

Forty observer-raters were recruited from the general lay population in a city center. These participants consented to having their eyes tracked while observing 40 images that were randomly displayed on a computer screen. Thus, each image was viewed by 40 individuals. Visual acuity testing was also performed and 20/40 vision or better was required in each eye for inclusion (lens correction permitted). Observers' gender (13 female and 27 male) and age (mean = 41.9 years, range = 16–72) were reported. After completion of the slideshow, the observers were asked to estimate the age of the 40 patients depicted in the images, and then judge the faces employing a Likert scale of 1 (least) to 7 (most) for the following character attributes: attractiveness, trustworthiness, sociability, health, and capability. To provide the observers with visual anchors, sample open-source images of men and women representing extremes of the scale (based on authors' judgment) were presented at the beginning of each survey.

Fig. 1. Representative patient images before (A) and after (B) facial rejuvenation surgery.

Eye-tracking Protocol

The 40 stimulus images portrayed pre- and postoperative photographs of patients who underwent high superficial musculoaponeurotic system (SMAS) facelift, with or without fat grafting, browlift, chin augmentation, lip augmentation, and upper and lower blepharoplasty. Photographs were obtained before and at least 3 months following the surgical intervention. Study images were presented to observers on a 17″ flat screen computer monitor for a total of 6 seconds. Seven minutes was required for study participants to complete observation of the entire 40-image slideshow. A 3-second blank, black interval was displayed between images. No specific instructions were given to the observers other than to view the images freely. Quick Screen Capture software (version 3.0, Etrusoft, Kaysville, Utah) was used to present PowerPoint (Microsoft Corp, Redmond, Wash.) slideshows containing the image stimuli, and these were displayed in random order from one subject to another. An EyeTech TM4 desktop-mounted, high resolution eye-tracking system was utilized (EyeTech Digital Systems, Mesa, Ariz.) which captures infrared light reflected off the cornea with a binocular data tracking rate of 30 Hz, and an accuracy of 0.5 degrees visual angle. The low-profile TM4 console was placed unobtrusively at the base of the computer monitor. Each participant's head was held stationary in an optometric chinrest 60 cm from the monitor. At that distance,

and with the eye-tracking system reporting an accuracy of ±0.5 degrees visual angle, the maximum eye-tracking error is calculated to be ±5 mm. Even the smallest region of interest on the faces in the study, when projected onto the 17-inch monitor, measured at least 1.4 cm in each dimension, with an area of at least 2 cm^2.

The eye-tracking procedure commenced with a calibration sequence in which participants were asked to track a dot displayed randomly at nine different locations on the screen. The system was calibrated on a per subject basis.

Nineteen aesthetic regions of interest ("lookzones") were hand-drawn onto each image using predetermined anatomic landmarks used in advance of the study (Fig. 2). The numbered look zones were consistent across all patients. The neck as well as nine matched bilateral facial zones were identified on each image, classified as forehead (1, 2); eye and brow (3, 4); glabellar (5, 6); lower eyelid (7, 8); nasal dorsum (9, 10); mid-cheek (11, 12); nasal tip and alae (13, 14); upper lip (15, 16); lower lip, chin, mandible (17, 18); and neck (19). The lookzones were overlaid onto the images post hoc, and thus, were unseen by the observers. EyeTech's Quick Link API software was used to compute real time data from the eye-tracking system which captured the X, Y position of the eye during each 33-millisecond interval. Fixation count and duration—relative to each facial aesthetic lookzone—was computed. A fixation was defined as a gaze duration of greater than 100 milliseconds. All information was imported from Excel (Microsoft, Redmond, Wash.) files to SPSS v.22.0 (IBM, Armonk, N.Y.) and analyzed in relation to the demographic/diagnostic details of the stimulus and observer groups.

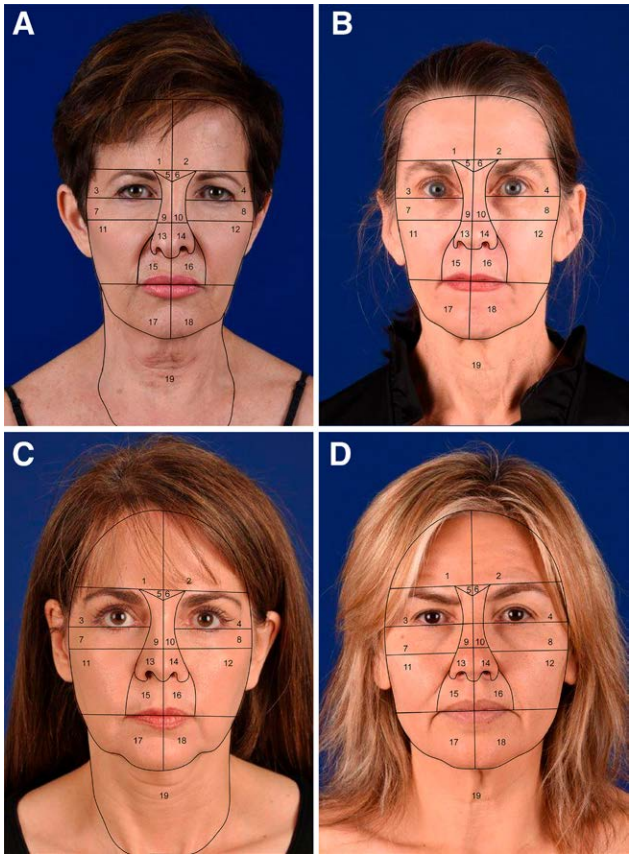

Fig. 2. Representative images of the overlayed hand-annotated lookzones for four experimental images (A-D) using predetermined anatomic landmarks. Nine matching zones were identified on each side of the face with one zone for the neck. They are classified as the following: forehead (1, 2); eye and brow (3, 4); glabellar (5, 6); lower eyelid (7,8); nasal dorsum (9, 10); mid-cheek (11, 12); nasal tip and alae (13, 14); upper lip (15, 16); lower lip, chin, mandible (17, 18); and neck (19).

DATA ANALYSIS

All data analyses were conducted in SPSS v.22.0 (IBM). Visualization of the data was facilitated with Tableau version 8.3.3 (Tableau Software, Seattle, Wash.). Mean fixation counts and fixation durations were computed across all 19 lookzones. The interaction effect of a variety of independent variables on lookzone fixation was analyzed using factorial ANOVA testing. Significance was set at the P less than 0.05 level.

RESULTS

Participant and Procedural Details

The 20 patients whose images were presented to observers had a mean age of 57.4 years old with a range from 41 to 70 years old (16 women, 4 men). Other concomitant procedures in addition to the rhytidectomy included 14 patients with browlift, 16 patients with upper plus/minus lower blepharoplasty, 18 patients with fat grafting to the face, four patients with upper and/or lower lip augmentation with fat, and three patients with chin augmentation with implants (**see table, Supplemental Digital Content 1**, which shows concomitant procedure frequency among the examined facial rejuvenation cohort, **http://links.lww.com/PRSGO/C715**). The observers' age ranged from 16 to 72 years with a mean of 41.9 years (13 women, 27 men). All observers except for one had completed more than an eighth-grade level education.

Proportion of Total Facial Visual Fixation, by Lookzone

The eye-tracking analysis uncovered interesting findings with respect to observers' unconscious, reactive responses to the patient images. With respect to the lookzones of the face, a similar regional distribution of visual attention was measured for the pre- and postoperative stimuli, with preferential attention paid to the region of the eyes and mouth, as expected (Fig. 3). A statistically coherent but nonsignificant ($P > 0.05$) trend was identified with the surgical intervention resulting in even greater attention being paid to the eye and brow, lower eyelid, upper lip, and nasal tip and alar regions (increases of 1%, 6.7%, 2.6%, and 12.4%, respectively), and a postintervention reduction in attention toward the forehead, glabella, mid-cheek, neck, nasal sidewall, and lower lip regions (reduction of 13.8%, 11%, 3.8%, 17.9%, 6.8%, and 2.2%, respectively).

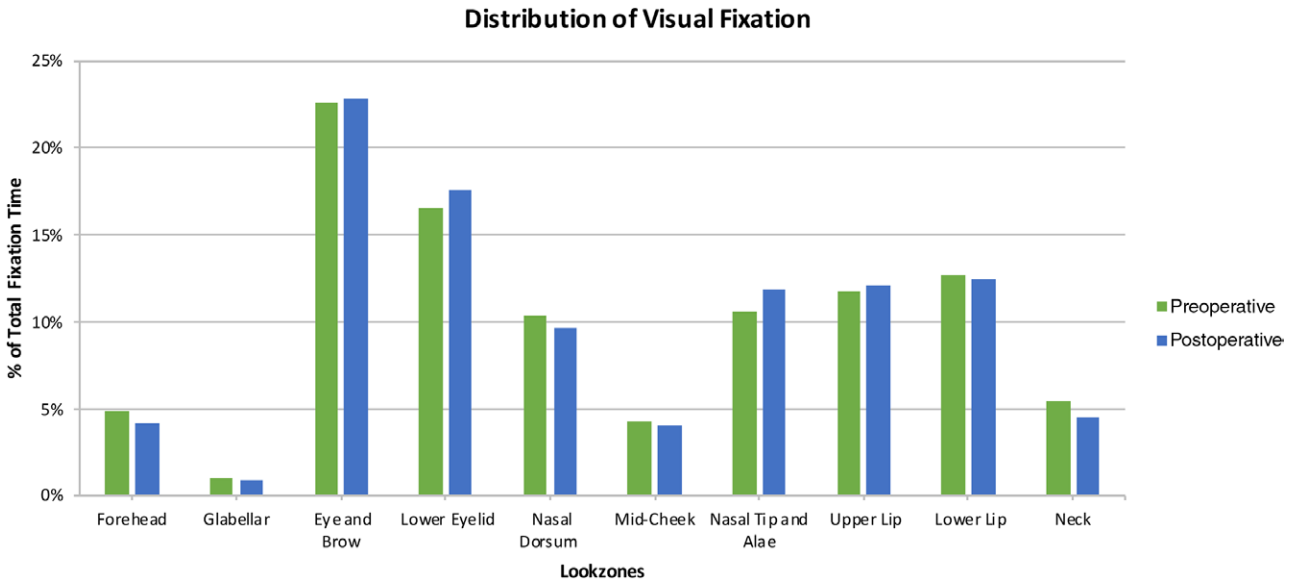

Fig. 3. Distribution of observers' visual fixation spent in each lookzone as a percentage of the total time examining the image. Bilateral lookzones were grouped together for a total of nine pairs, and the neck was considered a single lookzone.

Impact of Surgical Intervention on Character Attribution and Estimation of Age

Character attribution was broadly affected by the facial rejuvenation procedure. As demonstrated in Figure 4, the surgical intervention was found to increase the overall rating for all five-character attributes. The increase from pre- to postoperative ratings were as follows: attractiveness (3.34–3.90, 16.8% increase); capability (3.91–4.43, 13.3% increase); healthy (4.07–4.61, 13.3% increase); sociable (3.53–4.18, 18.4% increase); and trustworthy (3.85–4.20, 9% increase) (Fig. 5). These changes were all statistically significant ($P < 0.001$).

The observers estimated the average age of the patients in the study images to be 54 years (range 44.9–65.0) preoperatively and 48.6 years (range 40.5–59.5) postoperatively. The true mean age of the facial rejuvenation patients was 57.4 (range 41–68). The postoperative age estimate compared to the true age and to the preoperative age estimate were both reduced in a statistically significant manner ($P = 0.0001$ and 0.0004, respectively). Preoperative age estimate compared to true age was statistically insignificant ($P = 0.146$).

DISCUSSION

In 2019, the most recent year of pre-COVID-19 statistics available from the American Society of Plastic Surgeons, 261,987 facelifts, 181,024 neck lifts, 354,105 blepharoplasties, and 89,246 forehead lifts were performed by American Society of Plastic Surgeons member surgeons.[10] This represents a remarkable 105% increase in the total number of those particular procedures being reported relative to 5 years earlier in 2014.[11] These data underscore the increasing importance that the public places on the projection of a youthful face. Accordingly, it is incumbent upon the plastic surgeon to understand the critical elements of facial aging that are most salient to the casual observer.

Human visual inspection of a face is instinctively drawn toward a central discriminating zone encompassing the ocular, nasal, and oral regions.[12] However, when encountering a face affected by congenital or acquired deformity, observer attention is partially reallocated to areas perceived as anomalous. Although patient self-assessment tools,[3] quantitative measurement scales,[4] and national procedural statistics all provide valuable clues as to patient priorities and the parameters of facial aging, none of those sources of information yield insight into observers' subconscious reaction to a face. Spontaneous visual fixation corresponds closely with observer cognitive attention,[13,14] and because humans intuitively detect structural outliers, the use of eye-tracking technology represents an objective means of measuring consequential facial differences. Due to the fact that eye-tracking data reflect instinctive responses, they bypass any confounding that might exist from the known divergence of explicit (reported) and implicit (latent) attitudes.[15,16]

In this study, we tested whether the subliminal appraisal of facial aging is similar to what has been previously shown for other acquired facial irregularities such as skin lesions,[17] nasal distortion,[18] or facial palsy.[19] A two-part research question was: "Do regions of facial elastosis attract the reflexive visual attention of observers and, if so, does facial rejuvenative surgery reverse that objective phenomenon?" As an accompanying inquiry, we surveyed observers' subjective character attribution with regard to the same facial stimuli, searching for possible association between the objective and subjective measures.

Prior eye-tracking work by Liao et al showed that when tasked with estimating age, observers focus more attention on the lower third of the face,[20] reflecting the joint impact

Fig. 4. Trends represented in Figure 3, above, are depicted graphically here on our representative preoperative (A) and post-operative (B) images. With effacement of forehead and cheek rhytids, exposure of the periorbital area, and smoothening of the jawline and cervicomental region, there was an inclination for observers' attention to be redirected to the preferred central zones (shaded in green) and away from the more peripheral zones of the face (unshaded), as shown in image C.

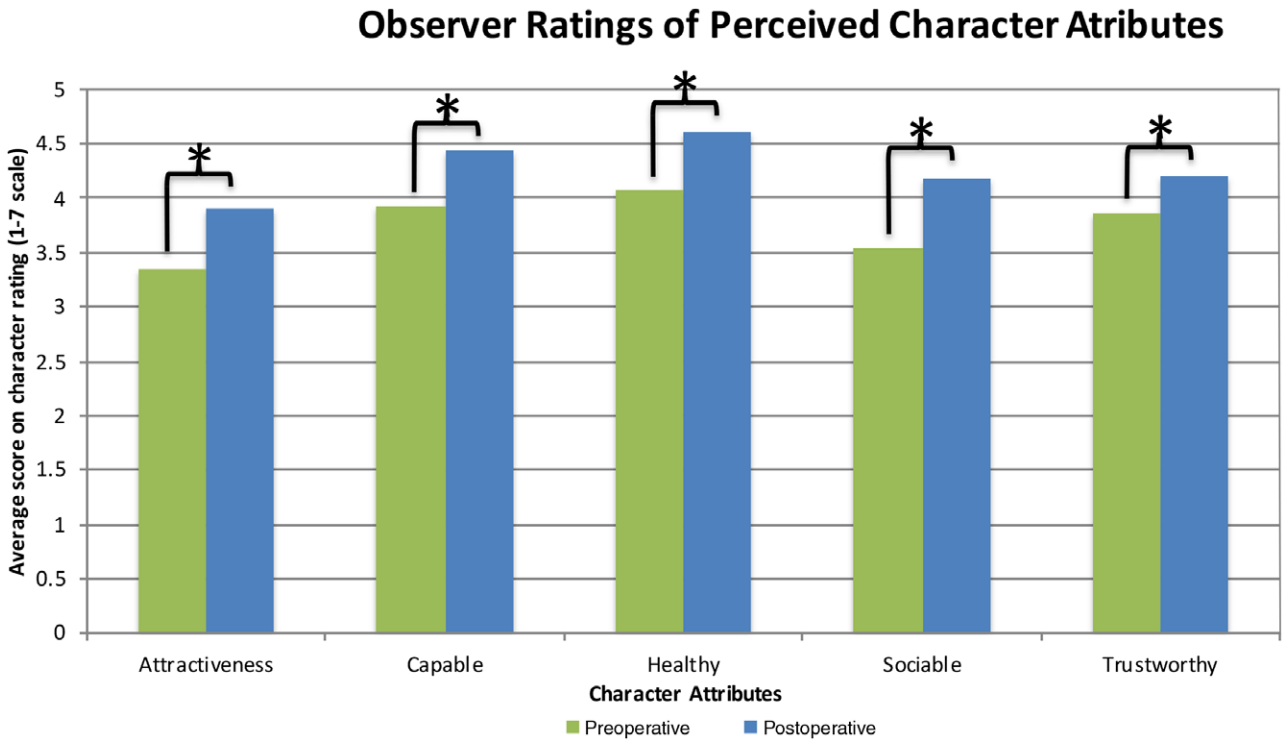

Fig. 5. The facial rejuvenative surgical intervention was found to increase the overall rating for all five positive valenced character attributes. *P <0.001.

of elastosis and gravity. Moreover, despite the human instinct for outlier detection when viewing a face,[10] Cai et al showed that more "experienced" observers (such as facial aesthetic surgeons) when asked to rate a face on the basis of beauty, directed their gaze more evenly across the face; uninitiated viewers were more naturally drawn to the central facial triangle.[21]

It stands to reason that an observer's viewpoint also impacts gaze pattern. Huynh et al[22] compared visual fixation with respect to the lateral versus frontal perspectives of a face. They were able to discern a shift of observers' primary focus from eye/nose/mouth (when viewing frontal) to eye/nose/cheek (when viewing lateral). Certain limitations of the study, however, restrict extrapolation of their findings to our work: (1) their image stimuli were not demographically characterized (the one representative image displayed is of a youthful face); (2) they did not undertake a pre- versus postoperative eye-tracking comparison; and (3) their viewing cohort had a mean age of 23.6 years. Recently, Frautschi et al ran a pre- and postoperative eye-tracking comparison of surgically rejuvenated faces and were able to detect significant experimental differences in

gaze patterns of treated faces.[23] This was despite the fact that their protocol was less powered than ours (11 versus 20 patients imaged, 25 versus 40 observers), and their observers were also younger (mean 32.0 versus 41.9 years) which arguably would make them less sensitive to detecting age-related facial changes. The sensitivity to facial features based on age was investigated by Murray et al.[24] The rate of adjunctive facial rejuvenative procedures in their study was notably lower than ours (eg, browlift, 18% versus 80%; blepharoplasty, 63% versus 80%; lipofilling, 36% versus 90%). They considered visual fixation relative to both aesthetic lookzones of the face as well as to three broad vertical regions. Observers viewed frontal, lateral, and oblique facial images, and from all three perspectives measured decreased visual attention paid to the neck and more to the middle third of the face in the postoperative cohort. In the current study, we measured observer gaze patterns with respect to frontal images of patients both before and after they underwent facial rejuvenation. We also explored a possible association between the reflexive gaze pattern and subjective character attribution relative to the pre- and postoperative facial images. The mean age of our patient group was 57.4 years, and the mean age of the observers was 41.9 years. All patients underwent a comprehensive facial rejuvenation including a high SMAS facelift procedure (100%), fat grafting (90%), bilateral upper plus/minus lower blepharoplasty (80%), and browlift (70%).

With respect to how observers' eyes tracked our experimental faces, a statistically coherent but nonsignificant ($P > 0.05$) trend was identified with the surgical intervention spurring greater attention toward the expressive central triangle region of the face and a reduction in gaze directed toward the facial periphery. This suggests that observers subconsciously detect peripheral elastosis as a distracting structural anomaly. The lack of statistical significance in this finding may be explained by the fact that the comprehensive package of rejuvenative interventions performed in our study impacted a broad array of the facial lookzones considered, perhaps more so than in the Frautschi protocol where the dominant intervention was a rhytidectomy. Similarly, whereas prior eye-tracking studies focused more narrowly on targets such as cleft lip deformity,[10] nasal dorsal deviation,[24] or periorbital aging,[25] the suite of surgical procedures considered here altered the brow, periorbital region, nasolabial folds, marionette lines, lips, jowls, and cervicomental region. It is reasonable to infer that such an extensive transformation of the face would provoke a holistic change in the pattern of observer visual fixation, countering the likelihood for detection of a prevailing measurable change in any one particular lookzone.

The other factor to consider—alluded to above—is observer perspective. As reflected in Figure 6, the lateral viewpoint may better highlight elastotic changes preoperatively in the cervicomental region, and improvement achieved in that region following rhytidectomy. Our current protocol was presumably insensitive to those findings, arguing for further eye-tracking investigation in the future to analyze the effects of facial rejuvenation from various frames of viewer reference.

In terms of character attribution in response to faces, a large body of research suggests that observers' perceptual

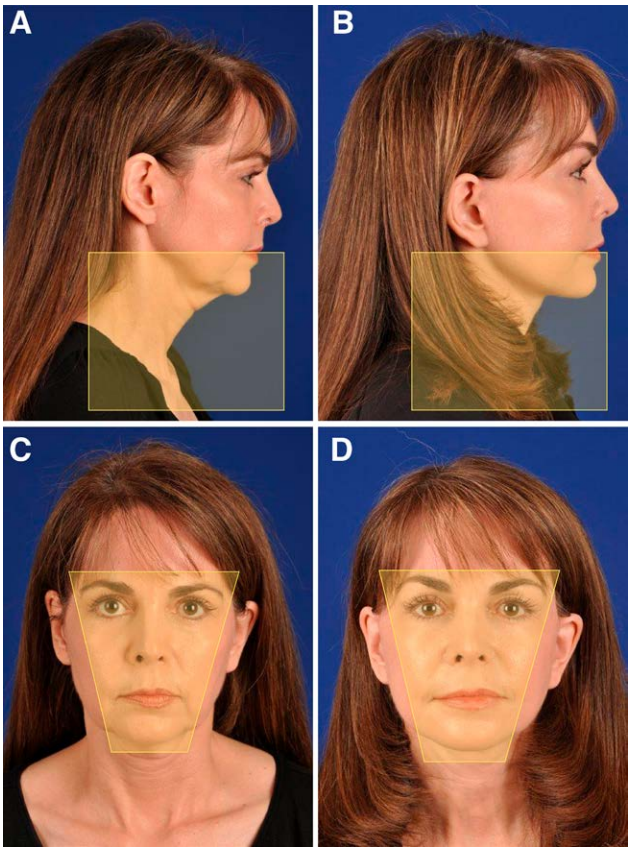

Fig. 6. Lateral preoperative (A) and postoperative (B) views of a representative patient. The lateral perspective highlights a preponderance of visible change in the cervicomental region, whereas the forehead and periorbital changes are more apparent from the frontal orientation (C-D).

reactions are almost instantaneous, and that the factors impacting impression formation (eg, age, gender, attractiveness, shape, lighting, skin tone, etc.) are multifactorial and challenging to parse.[21,26,27] Although all five of the positively valanced characteristics that we measured significantly increased with surgical rejuvenation, as seen in Figure 5, it is plausible that the attributes we considered are co-related. For example, the impression of "more attractive" might commingle with the notion of "more healthy" and "more trustworthy," whereas "more healthy" might align with "more attractive" and "more trustworthy," and so on. Nevertheless, it is notable that all five metrics were enhanced significantly and in tandem, along with a perceived reduction in the estimated age of the imaged faces from 54 to 48.6 years (true average: 57.4 years). The preoperative estimated age and the true age were not significantly different, demonstrating a lack of baseline observer bias towards rating faces younger than their true age.

The presented findings are not without limitation due to study design. Although the protocol was restricted to the evaluation of faces in repose, there is certainly a possibility that some subtle unintended expression of emotion was revealed by patients despite instructions to remain neutral. Potentially confounding elements which may subconsciously impact viewers' gaze include fine alterations

in lighting or variation in accessory aesthetics such as hairstyle or makeup. Moreover, the patients were racially homogenous (all low Fitzpatrick skin types), which could limit the generalizability of our results. The most crucial limitation of our study may be the fact that we considered only frontal facial images. It is highly likely that examination of oblique and profile views of aging faces will elicit alternative patterns of observer gaze since elastosis is manifested and detected differently within different zones of the face. Finally, attempting to study a cohort of patients undergoing rejuvenative procedures exclusively in the lower third of the face may allow for a more focused assessment of the impact of elastotic aging changes in that facial region. The impact of all these various factors not considered here could well serve as the focus for worthwhile future investigation.

Taken together, the findings reported here suggest that the changes of facial elastosis are perceived as structural outliers that lure observer attention away from the central discriminating features of the face, and are associated with a latent reduction in the assignment of positive character attributes. This information may assist surgeons and their patients to better understand the critical elements of facial aging that are most salient to the casual observer, thereby facilitating a more meaningful discussion around treatment options and benefits available.

CONCLUSIONS

We provide data illustrating both reflexive and subjective responses to facial rejuvenation. Observers reported a more favorable impression of the treated faces and evaluated them as being younger than their true age. A trend was detected towards increased visual fixation on the central facial region following rejuvenation. The impact of observer perspective was considered and suggests the need for further research to refine our understanding of the perception of facial aging and the benefits of available corrective surgical interventions.

Thanapoom Boonipat, MD
Mayo Clinic
200 First Street SW
Rochester, MN 55905
E-mail: Boonipat.thanapoom@mayo.edu

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Patients provided written consent for the use of their images.

REFERENCES

1. Kahneman D. A perspective on judgment and choice: mapping bounded rationality. *Am Psychol.* 2003;58:697–720.
2. Willis J, Todorov A. First impressions: making up your mind after a 100-ms exposure to a face. *Psychol Sci.* 2006;17:592–598.
3. Berger M, Weigert R, Pascal E, et al. Assessing improvement of patient satisfaction following facelift surgery using the FACE-Q scales: a prospective and multicenter study. *Aesthetic Plast Surg.* 2019;43:370–375.
4. Hersant B, Abbou R, SidAhmed-Mezi M, et al. Assessment tools for facial rejuvenation treatment: a review. *Aesthetic Plast Surg.* 2016;40:556–565.
5. Boonipat T, Brazile TL, Darwish OA, et al. Measuring visual attention to faces with cleft deformity. *J Plast Reconstr Aesthet Surg: JPRAS.* 2019;72:982–989.
6. Ramon M, Sokhn N, Caldara R. Decisional space modulates visual categorization—evidence from saccadic reaction times. *Cognition.* 2019;186:42–49.
7. Rayner K. Eye movements in reading and information processing: 20 years of research. *Psychol Bull.* 1998;124:372–422.
8. Yarbus AL. Eye movements during perception of complex objects. In: Yarbus AL, ed. *Eye Movements and Vision.* Boston, Mass.: Springer US; 1967:171–211.
9. Mackworth NH, Bruner JS. How adults and children search and recognize pictures. *Hum Dev.* 1970;13:149–177.
10. American Society of Plastic Surgeons. 2020 Plastic Surgery Statistics. Available at https://www.plasticsurgery.org/news/plastic-surgery-statistics. Accessed May 7, 2023.
11. American Society of Plastic Surgeons. 2014 Plastic Surgery Statistics. Available at https://www.plasticsurgery.org/news/plastic-surgery-statistics?sub=2014+Plastic+Surgery+Statistics. Accessed May 7, 2023.
12. Walker-Smith GJ, Gale AG, Findlay JM. Eye movement strategies involved in face perception. *Perception.* 1977;6:313–326.
13. Nixon HK. Attention and interest in advertising. *Arch Psyc.* 1924;72.
14. Chandon P, Hutchinson JW, Bradlow ET, et al. does in-store marketing work? effects of the number and position of shelf facings on brand attention and evaluation at the point of purchase. *J Marketing.* 2009;73:1–17.
15. Stone A, Wright T. Evaluations of people depicted with facial disfigurement compared to those with mobility impairment. *Basic Appl Soc Psychol.* 2012;34:212–225.
16. Rydell RJ, McConnell AR, Strain LM, et al. Implicit and explicit attitudes respond differently to increasing amounts of counterattitudinal information. *Eur J Soc Psychol.* 2007;37:867–878.
17. Ishii L, Carey J, Byrne P, et al. Measuring attentional bias to peripheral facial deformities. *Laryngoscope.* 2009;119:459–465.
18. Godoy A, Ishii M, Byrne PJ, et al. The straight truth: measuring observer attention to the crooked nose. *Laryngoscope.* 2011;121:937–941.
19. Ishii L, Dey J, Boahene KD, et al. The social distraction of facial paralysis: objective measurement of social attention using eye-tracking. *Laryngoscope.* 2016;126:334–339.
20. Liao D, Ishii LE, Chen J, et al. How old do I look? exploring the facial cues of age in a tasked eye-tracking study. *Facial Plast Surg Aesthet Med.* 2020;22:36–41.
21. Sutherland CA, Oldmeadow JA, Santos IM, et al. Social inferences from faces: ambient images generate a three-dimensional model. *Cognition.* 2013;127:105–118.
22. Huynh PP, Ishii M, Juarez M, et al. Normal gaze patterns of the face in lateral view. *Facial Plast Surg Aesthet Med.* 2020;22:80–85.
23. Frautschi RS, Dawlagala N, Klingemier EW, et al. The use of eye tracking technology in aesthetic surgery: analyzing changes in facial attention following surgery. *Aesthet Surg J.* 2020;40:1269–1279.
24. Murray JE, Halberstadt J, Ruffman T. The face of aging: sensitivity to facial feature relations changes with age. *Psychol Aging.* 2010;25:846–850.
25. Boonipat T, AbuGhname A, Garcia-Gonzalo E, et al. Impact of surgical rejuvenation on visual processing and character attribution of periorbital aging. *Plast Reconstr Surg.* 2022;150:539–548.
26. Cogsdill EJ, Todorov AT, Spelke ES, et al. Inferring character from faces: a developmental study. *Psychol Sci.* 2014;25:1132–1139.
27. Todorov A, Olivola CY, Dotsch R, et al. Social attributions from faces: determinants, consequences, accuracy, and functional significance. *Annu Rev Psychol.* 2015;66:519–545.